Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and	)	ET Docket No. 14-165
	)	GN Docket No. 12-268
Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	

To: The Commission

PETITION FOR RECONSIDERATION OF GE HEALTHCARE

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Pursuant to Section 1.429 of the Federal Communications Commission's ("Commission" or "FCC") rules, GE Healthcare ("GEHC")[1] respectfully submits this Petition for Reconsideration of the Commission's *Report and Order* ("*Part 15 R&O*") in the above-captioned proceedings.[2]

[1] GEHC is a unit of General Electric Company and provides a broad range of products and services that enable healthcare providers to better diagnose and treat diseases and medical conditions, including products and services that incorporate wireless technology.

[2] *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, et al.*, Report and Order, 30 FCC Rcd 9551 (2015) ("*Part 15 R&O*").

I. INTRODUCTION AND SUMMARY.

The Commission has long recognized the importance of Wireless Medical Telemetry Service ("WMTS") to patient care and the critical need to protect its "safety-of-life" operations from harmful interference.[3] As a safety-of-life service, WMTS cannot tolerate even small or episodic incidents of interference. For example, a single source of interference can cripple an entire WMTS system and be extremely difficult to identify, all the while endangering patients and diverting the attention of hospital staff. Given this sensitivity to interference and the safety-of-life nature of WMTS, the Commission vowed to be "conservative in [its] determination of protection distances to protect WMTS."[4]

Unfortunately, the Commission has failed to meet this goal. In the *Part 15 R&O*, the Commission adopted protection distances based on a flawed methodology that caused it to underestimate the distances required to protect WMTS systems from harmful interference from white space devices operating on Channel 37. For example, the Commission erroneously assumed that WMTS receive antennas operate at a height above ground level of 10 meters or less and incorporated height above average terrain ("HAAT") into its analysis in a way that leads to absurd results in many cases.[5]

The Commission also used an inappropriate propagation model and then misapplied that model while calculating the WMTS separation distances. For example, the Commission neglected to include a factor for the Signal to Noise Ratio ("SNR") required by WMTS radios, ignored the potential for multiple white space device interferors, and again wrongly assumed that

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[3] *See, e.g.*, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567 (2014) ("*Incentive Auction R&O*").

[4] *See Part 15 R&O* ¶ 202.

[5] *See Part 15 R&O* ¶ 210 n.535.

most WMTS antennas are no more than 10 meters high. By GEHC's calculations, correcting these three errors alone would cause the TM 91-1 model to yield protection distances that are about triple the distances adopted in the *Part 15 R&O*.

In addition, the Commission misinterpreted the results of real-world interference and path-loss tests performed by GEHC and the WMTS Coalition at three hospitals earlier this year. These tests confirmed that the TM 91-1 model overestimates path loss over short distances and line-of-sight conditions. They also confirmed that significant harmful interference can be caused to WMTS systems from even a single white space device operating at the power levels, separation distance, and height allowed by the Commission's rules. Finally, the Commission ignored concerns raised in the record about the security of white space devices and the white space database.

The Administrative Procedure Act ("APA") requires agency actions to be set aside if they are "arbitrary, capricious, [or] an abuse of discretion."[6] Under the APA, an agency acts arbitrarily and capriciously when it "fail[s] to consider an important aspect of the problem."[7] The initial rules released by the Commission violate the APA and should be revised.

GEHC requests that the Commission reconsider the WMTS protection distances adopted in the *Part 15 R&O*. The Commission should eliminate the material errors that plagued its initial analysis and adopt alternative protection distances that will, in fact, provide adequate protection to WMTS systems from white space devices operating on Channel 37. GEHC also requests that the Commission create an Institutional Review Board to oversee the initial deployment of white space devices on Channel 37 to help mitigate the potential harms to hospitals and patients. In

[6] *See* 5 U.S.C. § 706.

[7] *See Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto Ins. Co.*, 463 U.S. 29, 43 (1983).

addition, GEHC requests that the Commission reconsider its decision to allow white space devices to operate on Channel 37 before addressing the dependability concerns that currently exist concerning those devices and the geolocation-database scheme as a whole.

In the meantime, GEHC continues to engage with Google in cooperation with the WMTS Coalition on many of the issues raised in this proceeding. We sincerely believe that the alternative automated coordination approach that we and the WMTS Coalition have suggested and discussed with Google would be far more useful to all of the stakeholders in this proceeding than the Commission's current regime.[8]

II. THE COMMISSION'S ANALYSIS INCLUDES A NUMBER OF MATERIAL ERRORS THAT CAUSE IT TO UNDERESTIMATE THE DISTANCES REQUIRED TO PROTECT WMTS SYSTEMS FROM HARMFUL INTERFERENCE.

The Commission's analysis contains a number of material errors that cause it to severely underestimate the distances required to keep white space devices from interfering with safety-of-life WMTS systems in Channel 37. Among other things, the Commission erroneously assumes a 10 meter or less height for WMTS receive antenna and uses height above average terrain ("HAAT") in a way that leads to absurd results in many cases. Each of these errors independently increases the risk of harmful interference to WMTS systems. Together, they significantly increase the likelihood of harmful interference by yielding separation distances that are insufficient to protect WMTS systems in many instances. In fact, the Commission's analysis was so skewed that safety-of-life WMTS operations are now afforded less protection from co-channel interference than non-safety-of-life digital television receivers or wireless operations in

[8] *See, e.g.*, Letter from Dale Woodin, Executive Director, American Society for Healthcare Engineering, *et al*., to Tom Wheeler, Chairman, FCC, *et al*., ET Docket No. 14-165 (filed July 21, 2015) ("ASHE July 21, 2015 *Ex Parte* Letter").

the 600 MHz band. Meanwhile, WMTS systems are also at greater risk of harmful adjacent channel interference now because the Commission simultaneously removed the explicit protection of Channel 37 and increased the out-of-band emissions allowed from white space devices operating in non-adjacent channels.

A. The Commission's erroneous assumption that WMTS receive antennas are at a height of no greater than 10 meters caused it to adopt separation distances that will make a significant number of hospitals vulnerable to harmful interference.

GEHC warned in its comments that the Commission's proposal incorrectly assumed that the tallest WMTS facility is 10 meters above ground level ("AGL").[9] GEHC even submitted a histogram of WMTS system heights by floor count, which demonstrated that the majority of WMTS systems are located at heights AGL that exceed 10 meters.[10] The Commission disagreed with GEHC's "characterization" of the data, claiming that the histogram showed the heights of hospitals with WMTS systems and that it would be "unreasonable to assume that every WMTS device at every facility is located on the top floor."[11] The Commission also suggested that the taller hospitals will be protected from interference because they are located "in urban areas where losses due to shadowing and multipath will be greater."[12] However, neither of the Commission's reasons for continuing to use a 10 meter height withstands scrutiny under a rational basis review.

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[9] *See* Comments of GE Healthcare, ET Docket No. 14-165, GN Docket No. 12-268, at 21-22 (filed Feb. 4, 2015) ("GEHC Comments").

[10] *See id*.

[11] *See Part 15 R&O* ¶ 210.

[12] *See id.*

As an initial matter, the Commission incorrectly interpreted GEHC's histogram. The histogram does not show the height of the hospitals with WMTS systems.[13] Instead, it shows the top floor in which WMTS receive antennas are deployed in those hospitals.[14] For example, a seven story hospital in which the fourth floor is the highest floor on which the WMTS is installed appears in the histogram under "4" instead of "7." In fact, the histogram was even titled "Max Height of WMTS Deployment."[15]

Moreover, the Commission's claim that taller hospitals are "likely to be located in urban areas where losses due to shadowing and multipath will be greater" is unsupported and contrary to the available evidence in this proceeding.[16] For example, the American Society for Healthcare Engineering ("ASHE") has submitted numerous photographs that show tall hospitals that are located in areas with little or no obstructions.[17]

B. The Commission misunderstood GEHC's concerns about using HAAT to calculate protection distances.

In its comments, GEHC also warned that using HAAT to calculate all protection distances would lead to absurd results in some cases.[18] GEHC pointed out that HAAT is "primarily useful in scenarios where the transmitter is providing coverage to a very large area."[19] GEHC also pointed out that transmitter antenna AGL is "the only meaningful way to measure

[13] *See* GEHC Comments at 21-22.

[14] *See id*.

[15] *See id*. (emphasis added).

[16] *See Part 15 R&O* ¶ 210.

[17] *See* Letter from Lawrence J. Movshin, Counsel, ASHE, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165, GN Docket No. 12-268 (filed Apr. 29, 2015).

[18] *See* GEHC Comments at 22-24.

[19] *Id*. at 23.

the impact of transmitter antenna height" in cases where shorter distances are involved.[20] In response, the Commission asserted that "in these cases the HAAT and antenna height above ground level are the same and does not alter the analysis."[21] The Commission also observed that GEHC did not "offer any suggestions for alternative means of analysis" to this problem.[22]

The Commission missed GEHC's point, which was that using HAAT alone to define the maximum height of fixed or white space devices does not make sense in this case because the protection distances are relatively small. HAAT was developed for broadcast television signals and only considers terrain variations between 3 and 16 kilometers, which makes it useless for white spaces devices with relatively small coverage areas. The Commission's rules for calculating HAAT do not allow radials to be truncated for any reason other than extending over large bodies of water or foreign territory, so the full 3 to 16 kilometer HAAT calculation applies to all sites *regardless of the extent of their coverage areas*.[23] Meanwhile, the Commission's assertion that "in these cases the HAAT and antenna height above ground level are the same and does not alter the analysis" is completely untrue in almost all cases.[24] The only way the height of an antenna AGL can equal its HAAT is if the HAAT calculation results in an average elevation above mean sea level ("AMSL") of surrounding terrain (from 3 kilometers to 16 kilometers) that is exactly equal to the ground elevation AMSL of the site.

Many hospitals are located near rivers, bays, or oceans. In these situations, the average terrain from 3 to 16 kilometers around the hospital is typically at a higher elevation than the land

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[20] *Id*.

[21] *See Part 15 R&O* ¶ 210 n.535.

[22] *Id*.

[23] *See* 47 C.F.R. §§ 15.709(b)(2), 73.684(d).

[24] *See Part 15 R&O* ¶ 210 n.535. It is not clear which "cases" the Commission is referring to in this statement. *See id.*

near the hospital. This results in a HAAT that is negative both outside the hospital and at nearby locations where fixed white space devices could be deployed.

Meanwhile, when HAAT is negative at ground level, fixed white space devices whose power and distance from WMTS facilities is limited by HAAT can be mounted on very high towers located very close to hospitals, up to the 30 meter AGL maximum. For example, in an area where the HAAT is -27 meters at ground level, a fixed white space device that is 30 meters above ground can be deployed at the power levels and distances associated with the Fixed White Space Devices table's "Less than 3 meters" HAAT row.[25] That is, when the HAAT at ground level is less than -27 meters, fixed white space device deployments can occur at any height up to the Commission's maximum of 30 meters AGL and at the shortest distance from WMTS facilities allowed in the Commission's table.[26] For example, at locations where the HAAT at ground level is -27 meters or less, 30 meter fixed sites can be deployed within 380 meters of a WMTS facility at 40 mW EIRP, within 1.2 kilometers of a WMTS facility at 4 watts EIRP, or at any distance and power level in the Fixed White Space Devices table's "Less than 3 meters" HAAT row.[27] This puts hospitals in these areas at significantly greater risk of experiencing harmful interference from fixed white space devices compared to hospitals where the HAAT at ground level is a positive number.

The current white space database validates GEHC's concern. As of December 10, 2015, 616 fixed white space devices were registered in the database. Approximately 68 percent of

[25] *See Part 15 R&O* ¶ 211.

[26] *See id.*

[27] *See id.*

them, or 416 devices, are located in areas where the HAAT at ground level is negative.[28] In addition, approximately 38 percent are at locations where the HAAT at ground level is -27 meters or less. This means that approximately 38 percent of the fixed white space devices registered in the database today would be able to operate on Channel 37 at 30 meters AGL at the minimum distance from a WMTS facility.

In all, approximately 46 percent of the fixed white space devices registered in the database have an antenna radiation center that is less than 3 meters HAAT but greater than or equal to 3 meters AGL. Of these, 27 devices are at the maximum height of 30 meters AGL, and 109 devices are at a height of 10 meters AGL or greater. This means that a significant number of fixed white space devices would be able to operate at the shortest allowed distances from WMTS operating hospitals at heights above ground level that are greater than would be allowed if the HAAT at ground level were positive. In sum, the risk of harmful interference to WMTS systems will be greater at a significant number of hospitals because the Commission has not accounted for cases where HAAT is negative.

The tests performed by GEHC and the WMTS Coalition at Inova Mount Vernon Hospital also validate GEHC's concerns.[29] There, eight of the nine test locations had negative HAAT at ground level ranging from -26 to -27 meters.[30] Thus, fixed white space devices with antennas that are 29 to 30 meters above ground level could be located at the closest separation distance to

[28] The HAAT "at ground level" is the radiation center's HAAT minus the radiation center's AGL.

[29] *See* GEHC Comments at 25-27; GEHC Comments at App. A ("Inova Report").

[30] *See* Inova Report at 12. The source of interference in these tests was approximately 3 meters AGL, which means that the HAAT at ground level was approximately 3 meters lower than the HAAT values shown in Table 4 of the Inova Report. *See id.* at 8, 12; GEHC Comments at 23-24.

the hospital (300 – 400 meters) because, even at these great heights above the ground, the antennas meet the requirement for a HAAT of less than 3 meters.

One way to fix this problem is to apply power and distance limits based on the greater of the antenna's height above average terrain **or** the antenna's height above ground level. For example, the column heading the Commission's table could be changed to read: "Antenna height above average terrain or antenna height above ground level of unlicensed device, whichever is greater."[31] Such an adjustment would allow the Commission to better protect hospitals and patients in areas that have a negative HAAT by accounting for the impact of transmitter antenna height in these places. Meanwhile, if this problem is not fixed, the Commission will be ensuring that a significant number of hospital WMTS systems and their patients will experience harmful interference as a result of its actions in this proceeding.

C. The Commission afforded safety-of-life WMTS systems less protection from white space devices than DTV receivers or wireless operations in the 600 MHz band.

The Commission adopted a framework in the *Part 15 R&O* that affords critical, safety-of-life WMTS operations less protection from white space device interference than digital television ("DTV") receivers or wireless operations in the 600 MHz band. This result is counterintuitive and impossible to square with the Commission's professed goal of ensuring "conservative protection distances for WMTS receivers."[32] This result also suggests that the Commission erred dramatically when developing the minimum separation distances between white space devices and WMTS systems.

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[31] *See Part 15 R&O* ¶ 211.

[32] *See id.* ¶ 207.

The following chart illustrates the Commission's new protection distances for WMTS systems, digital receivers, and wireless operations in the 600 MHz band at different HAAT values and power levels. It shows that DTV receivers and wireless operations in the 600 MHz band are consistently provided with significantly larger protection distances:

Height Above Average Terrain of Unlicensed Device (m)		Tx EIRP (dBm/6 MHz)						
		16	20	24	28	32	36	40
Communicating with Mode II or Fixed Device	Unlicensed to WMTS	0.38	0.48	N/A	N/A	N/A	N/A	N/A
	Unlicensed to DTV	1.3	1.7	N/A	N/A	N/A	N/A	N/A
	Unlicensed to 600 MHz	5	6	N/A	N/A	N/A	N/A	N/A
Communicating with Mode I Device	Unlicensed to WMTS	0.76	0.96	N/A	N/A	N/A	N/A	N/A
	Unlicensed to DTV	2.6	3.4	N/A	N/A	N/A	N/A	N/A
	Unlicensed to 600 MHz	10	12	N/A	N/A	N/A	N/A	N/A
Less than 3 meters	Unlicensed to WMTS	0.38	0.48	0.60	0.76	0.96	1.20	N/A
	Unlicensed to DTV	1.3	1.7	2.1	2.7	3.3	4.0	4.5
	Unlicensed to 600 MHz	5	6	7	9	12	15	19
3-Less than 10 meters	Unlicensed to WMTS	0.70	0.88	1.10	1.38	1.74	2.20	N/A
	Unlicensed to DTV	2.4	3.1	3.8	4.8	6.1	7.3	8.5
	Unlicensed to 600 MHz	9	11	14	17	22	27	34
10-Less than 30 meters	Unlicensed to WMTS	1.20	1.55	1.95	2.45	3.05	3.80	N/A
	Unlicensed to DTV	4.2	5.1	6.0	7.1	8.9	11.1	13.9
	Unlicensed to 600 MHz	15	19	24	30	38	47	60
30-Less than 50 meters	Unlicensed to WMTS	1.55	2.00	2.50	3.15	3.95	4.95	N/A
	Unlicensed to DTV	5.4	6.5	7.7	9.2	11.5	14.3	19.1
	Unlicensed to 600 MHz	20	24	31	38	49	60	60
50-Less than 75 meters	Unlicensed to WMTS	1.90	2.45	3.05	3.85	4.85	6.10	N/A
	Unlicensed to DTV	6.6	7.9	9.4	11.1	13.9	18.0	23.8
	Unlicensed to 600 MHz	24	30	37	47	60	60	60
75-Less than 100 meters	Unlicensed to WMTS	2.20	2.80	3.55	4.45	5.60	7.05	N/A
	Unlicensed to DTV	7.7	9.2	10.9	12.8	17.2	21.1	27.2
	Unlicensed to 600 MHz	27	34	43	54	60	60	60
100-Less than 150 meters	Unlicensed to WMTS	2.70	3.45	4.35	5.45	6.85	8.65	N/A
	Unlicensed to DTV	9.4	11.1	13.2	16.5	21.4	25.3	32.3
	Unlicensed to 600 MHz	33	42	53	60	60	60	60
150-Less than 200 meters	Unlicensed to WMTS	3.15	3.95	5.00	6.30	7.90	9.95	N/A
	Unlicensed to DTV	10.9	12.7	15.8	19.5	24.7	28.5	36.4
	Unlicensed to 600 MHz	39	49	60	60	60	60	60
200-250 meters	Unlicensed to WMTS	3.50	4.40	5.60	7.00	8.80	11.00	N/A
	Unlicensed to DTV	12.1	14.3	18.2	22.0	27.3	31.2	39.5
	Unlicensed to 600 MHz	43	54	60	60	60	60	60

To facilitate protection from personal/portable white space devices, the Commission now requires only 380 meters separation between a 40 mW Mode II device and a hospital, but nearly 3.5 times this distance between the same device and a DTV contour (1.3 km) and more than 13

times this distance between the same device and a 600 MHz base station receiver (5 km). Meanwhile, to facilitate protection from fixed white space devices, the Commission now requires 5 to 60 kilometers separation between unlicensed devices operating co-channel on a 600 MHz uplink frequency and the perimeter of the primary 600 MHz deployment, from 1.3 to 31.2 km between unlicensed devices and a co-channel TV facility, but only .38 to 11 km between unlicensed devices and a co-channel WMTS facility. Consistent with the material errors identified above, these striking results suggest that the Commission's calculation of protection distances for WMTS systems was deeply flawed.

D. The Commission ignored the significant risk of harmful interference to WMTS systems from unlicensed operations inside hospitals created by simultaneously removing the explicit protection of Channel 37 and increasing the out-of-band emissions allowed from white space devices operating in non-adjacent channels.

While revising its rules to allow white space devices to operate in Channels 36 and 38, the Commission restructured its out-of-band emissions ("OOBE") regime in a way that significantly increases the risk of harmful interference to WMTS systems.[33] First, the Commission allowed unlicensed operation in the channels adjacent to Channel 37 and applied more relaxed OOBE limits into Channel 37 from the adjacent Channels 36 and 38 than had previously been allowed from operations in non-adjacent channels.[34] Second—and more

[33] *See Part 15 R&O* ¶¶ 235-37.

[34] *See id*. The limit on OOBE from Channels 36 and 38 had been expressly endorsed by the White Spaces Coalition, which included Google and Microsoft. It was carefully designed to protect WMTS systems from harmful interference due to spurious emissions from personal/portable white space devices located inside hospitals, even though such devices had not, at that point, been permitted to operate. *See* Letter from Edmond Thomas, Counsel, White Spaces Coalition, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 04-186 (filed July 11, 2008) (calling the agreement "a shining example of what can be achieved when incumbent operators are willing to work with proponents of which space operations"); *Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd 16807 ¶¶ 155, 234-36 (2008) (noting that "Dell, Inc. and Google support GE Healthcare's proposal for an emissions mask in channels 36 and 38 to protect WMTS devices").

importantly—the Commission also relaxed the OOBE limit from non-adjacent channels into Channel 37, which had previously required *all emissions* from white space devices into Channel 37 to be limited to 30 dBμV/m/120 kHz at a 1 meter distance.[35] This limit is equivalent to an EIRP limit in 608-614 MHz of -75.5 dBm/100 kHz.[36]

The rules adopted in the *Part 15 R&O* restrict unlicensed operations in Channels 36 and 38 from occurring within a specified radius of WMTS facilities, but do not restrict the location of operations in non-adjacent channels in any way. Thus, the increased levels of OOBE allowed in Channel 37 by operations in non-adjacent channels represents a significant interference risk to WMTS systems. Although operations in the adjacent Channels 36 and 38 will also increase the risk of harmful interference to WMTS systems, the required separation distances make this less of a concern than operations in non-adjacent channels, because these can occur inside a hospital, potentially a meter or less away from a WMTS antenna, and with much higher OOBE in Channel 37 than previously allowed. In some cases, these non-adjacent channel operations can even occur with higher OOBE in Channel 37 than is allowed from unlicensed operations in the adjacent Channels 36 and 38.

In other words, given that personal/portable white space devices may be operated (on channels other than 36-38) inside hospitals, the Commission has inexplicably abolished the very protection required to prevent harmful interference due to their OOBEs that fall into Channel 37. For OOBE from non-adjacent channels, the Commission's new rule allows emissions in Channel

[35] With the elimination of the 30 dBμV/m/120 kHz at 1 meter OOBE limit into Channel 37, the new rules for OOBE from non-adjacent channels into Channel 37 are now governed by Section 15.209 of the Commission's rules, which previously applied to emissions into all non-adjacent channels other than Channel 37. *See* 47 C.F.R. § 15.209. For the UHF band, this limit is 200 μV/m at 3 meters (*i.e.*, 46 dBμV/m at 3 meters). In equivalent units, this is about 55.5 dBμV/m at 1 meter. §15.209 does not specify the measurement bandwidth.

[36] *See Part 15 R&O* ¶¶ 235-37.

37 of 200 μV/m or 46 dBμV/m at 3 meters, which is equivalent to an EIRP of -49.2 dBm—an increase of 26.3 dB over the previous rule. The increased power levels into Channel 37 are very significant and will originate from white space devices operating in both adjacent and non-adjacent channels.

To avoid this interference risk, the 608-614 MHz OOBE limits provided in the initial emissions mask should be retained or, in the alternative, white space devices should be restricted from operating inside WMTS operating hospitals regardless of the channel they are assigned (*e.g.*, the same modest separation distances necessary for Channels 36 and 38 could be applied to all channels other than Channel 37).

E. The Commission wrongly assumed that the CSMAC used median signal strength to model interference between safety-of-life services.

In the *Part 15 R&O*, the Commission noted that there are "many instances where median signal strength has been used to model interference between services, including safety-of-life services," apparently to help justify its approach to developing WMTS protection distances.[37] As an example, the Commission cited the Commerce Spectrum Management Advisory Committee ("CSMAC").[38] It explained that CSMAC approved reports from a number of working groups and used median propagation statistics when evaluating the interference environment between commercial wireless operations and federal operations.[39] However, a closer look at the Commission's assumptions about the CSMAC reveals a number of problems.

[37] *See Part 15 R&O* ¶ 207.

[38] *See id.* ¶ 207 n.524.

[39] *See id.*

First, although the Commission is correct in noting that the CSMAC was "comprised of spectrum policy experts from the government and the wireless industry,"[40] its work was based on the National Telecommunications and Information Administration Fast Track Report, which itself was based on several unpublished Department of Defense ("DoD") studies where sharing analyses had already been completed using median-based approaches. By the time CSMAC began working on these issues, there was little opportunity to change the approach.

Second, the Commission refers to the efforts of Working Group 5, which addressed airborne operations.[41] The nature of these operations led to simulations and median analyses since the airborne and commercial systems are mobile and may be comprised of multiple propagation paths. It is also worth noting that of the four systems addressed by WG5 (PGM, ACT, SUAS, and AMT), the CSMAC work concluded that sharing with PGM and SUAS was not feasible.

Third, the Commission attempts to characterize Air Combat Training Systems ("ACTS") as a safety-of-life service.[42] However, nowhere in the CSMAC report or the Fast Track Report does DoD characterize ACTS as a safety-of-life operation.

Fourth, there was disagreement between commercial and DoD participants regarding the appropriate application of the propagation models (specifically regarding the clutter and terrain effects), interference protection criteria, and a more representative LTE model. DoD and wireless industry representatives formed a separate task force to study these issues, but could not reach agreement. Notably, the DoD is still considering how best to model propagation between

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[40] *See id.*

[41] *See id.*

[42] *See id.*

ground-based commercial systems and airborne systems. This work is being conducted under the DISA 5: Spectrum Sharing Test & Demonstration effort, as outlined in the DoD DISA DSO AWS-3 transition plan.[43]

Fifth, this CSMAC work was intended to refine the protection zones presented in the Fast Track report, but always with the intent that more detailed sharing analyses could be performed to "engineer" commercial systems for operation within the protection zones. That is one goal of the DoD's Early Entry Portal Analysis Capability ("EEPAC").

Sixth, for the use of median path loss predictions to be valid, it is necessary to account for the intrinsic variability of the real-world propagation about the median. This can be done explicitly as a distinct term in the minimum coupling loss equation or, alternatively, by incorporating additional margin within the protection criteria itself. In fact, the CSMAC analysis cited by the Commission appears to have taken the latter approach to mitigate against the expected propagation variability about the predicted median. For example, in the case of the safety-of-life aeronautical mobile telemetry ("AMT") service, the CSMAC analysis employs the protection criteria recommended in ITU-R M.1459 that itself builds in substantial margin for expected propagation variability.[44]

By contrast, the Commission's analysis failed to account for any expected interference propagation variability about the predicted median—neither by incorporating an explicit term in the minimum coupling loss equation, nor by employing a protection criteria for WMTS that builds in additional margin. Consequently, if the Commission is to continue using median path

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[43] *See, e.g.*, Howard McDonald, DoD, *Test and Measurement requirements DoD 1755-1780 MHz Spectrum Sharing Test & Demonstration (SSTD) Program* (May 13 2015), *available at* http://www.its.bldrdoc.gov/media/66264/mcdonald-isart-2015.pdf.

[44] *See* Recommendation ITU-R M.1459, Annex 1 § 2.2.1.

loss predictions in its TVWS/WMTS analysis, further adjustments will be required elsewhere in the analysis to account for reasonable worst-case interference propagation variability (*e.g.*, by introducing another term to the coupling equation that subtracts two standard deviations from the median prediction), so that the separation distances are sufficient to actually prevent interference in reasonable worst-case scenarios.

These distinctions between the CSMAC process and constraints and the goals and constraints at hand make the CSMAC's use of median signal strength an inappropriate precedent for modeling interference in this instance.

F. The Commission failed to consider the height at which personal/portable white space devices operate.

The Commission allowed both Mode I and Mode II personal/portable white space devices to operate on Channel 37 at power levels up to 100 milliwatts despite warnings from GEHC and others that the risk of harmful interference to WMTS systems is heightened with respect to such devices.[45] The Commission also failed to limit the height at which personal/portable white space devices may operate or even indicate that it had considered that the risk posed by such devices to WMTS systems will depend on this height but rather made the assumption that all personal/portable white space devices will operate at no greater than 3 meters HAAT.[46]

Given the very nature of these devices, there seems to be no rational basis for this assumption. Like the Commission's insistence on using HAAT and its assumption of a 10 meter

[45] *See Part 15 R&O* ¶ 198; *see also, e.g.*, GEHC Comments at 28-29; Comments of the WMTS Coalition, ET Docket No. 14-165, GN Docket No. 12-268, at 9-13 (filed Feb. 4, 2015) ("WMTS Coalition Comments").

[46] *See Part 15 R&O* ¶ 211 (using the same protection distances for personal-portable white space devices as for fixed white space devices with a HAAT of less than 3 meters, which effectively assumes a very low antenna height for each personal/portable white space device).

maximum height for all WMTS deployments to calculate all protection distances, the Commission's error here will increase the risk of harmful interference to WMTS systems and their patients at a significant number of hospitals. For example, personal/portable white space devices operating in front of clear glass windows on a high floor will experience very little attenuation. Likewise, residential and other building windows are sometimes open, and many high buildings have balconies and other outdoor living spaces where personal/portable white space devices could be located. Also, even when a personal/portable white space device is indoors at a location where there are significant building penetration losses, those losses may not be sufficient—especially on a high floor—to overcome the difference between the TM 91-1 model's prediction assuming 3 meters and the actual propagation from that floor, which potentially could approach free-space loss.

The use of a fixed 3 meter height is perplexing because it would not be difficult for the Commission to devise a system that takes into account the height of Mode II personal/portable white space devices, as GEHC suggested earlier in this proceeding.[47] Mode II personal/portable white space devices are required to have geolocation, so their positions should already be known in three dimensions. Thus, the Commission need only specify what protection distances apply at different person/portable white space device operation heights and powers, much like is has for fixed white space devices.[48]

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[47] *See, e.g.*, Reply Comments of GE Healthcare, ET Docket No. 14-165, GN Docket No. 12-268, at 15 n.50 (filed Feb. 25, 2015) ("GEHC Reply Comments") (stating that GEHC would support an interference mitigation that considers site-specific propagation conditions if it is "based on whitespace device locations and WMTS deployments in three dimensions" because "propagation conditions will depend on the vertical position of unlicensed devices, as well as the horizontal position").

[48] *See Part 15 R&O* ¶ 211.

Mode I personal/portable white space devices present a greater challenge since their exact location and height is unknown. Given the increased interference risk of Mode I devices operating from high floors, the Commission should adopt appropriately conservative additional separation distances to limit the distance from a WMTS facility of a Fixed or Mode II device that is communicating with a Mode I device. One option is to assume that the Mode I device is operating at the same height as the Fixed or Mode II device, which would essentially result in a doubling of the protection distance when communication is with a Mode I personal/portable white space device.

III. THE COMMISSION INAPPROPRIATELY CHOSE AND THEN MISAPPLIED THE TM 91-1 PROPAGATION MODEL TO CALCULATE PROTECTION DISTANCES.

A. The TM 91-1 model is fundamentally ill-suited for calculating protection distances between unlicensed devices and WMTS systems, as evidenced by it being identical to the Egli model.

GEHC and others warned the Commission throughout this proceeding that the TM 91-1 model is fundamentally ill-suited for predicting path loss between white space devices and WMTS systems operating in Channel 37.[49] For example, GEHC cautioned in its comments that the TM 91-1 model has several limitations that undermine its ability to generate protection distances that adequately protect most hospitals.[50] Nevertheless, the Commission used the TM 91-1 to calculate the WMTS protection distances and noted the similarities between it and the Egli model, which was developed more than 50 years ago to measure path loss over large distances and in very different circumstances.[51]

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[49] *See, e.g.*, GEHC Comments at 14-21; WMTS Coalition Comments at 15-16.

[50] *See* GEHC Comments at 14-21.

[51] *See* Jon Egli, *Radio Propagation Properties Above 40 Mc Over Irregular Terrain*, 45 Proceedings of the I.R.E. 1383 (1957) ("*Egli Report*").

In fact, the TM 91-1 model and the Egli model produce identical results when stated in the same units, which the Commission confirmed in the *Part 15 R&O*.[52] However, the Egli model was developed for broadcast television purposes. The measurements upon which the Egli model was based were taken in the 1940s and the 1950s, and the studies on which Egli relied focused on broadcast television.[53] For example, in the RCA study used by Egli, the transmitting antennas were located on New York City's Empire State Building at 1061 to 1250 feet above ground level and receive antennas were located at 30 feet, which is the typical height of a television antenna mounted on a two story house.[54]

The introductory paragraph of the TM 91-1 Technical Document confirms this and affirms the need for a model capable of predicting interference potential at shorter distances.[55] As that document explains, "[e]xisting field strength prediction models are generally intended for use at greater distances and were based on, and verified with, empirical data from these greater distances."[56] The TM 91-1 model does not meet this need, as it is indistinguishable from the Egli model. As a result, it is also not appropriate for predicting path loss between smaller distances—such as the protection distances between WMTS systems and white space devices in Channel 37.[57]

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[52] *See Part 15 R&O* ¶ 177.

[53] *See Egli Report*.

[54] *See* George H. Brown *et al*., *Comparative Propagation Measurements: Television Transmitters at 67.25, 288, 510, and 910 Megacycles*, 9 RCA REV. 171 (1948), *available at* http://www.americanradiohistory.com/Archive-RCA-Review/RCA-Review-1948-Jun.pdf.

[55] *See* Willian Daniel and Harry Wong, FCC, Office of Engineering and Technology, *Propagation in Suburban Areas at Distances Less than Ten Miles* (Jan. 25, 1991) ("TM 91-1 Technical Document"), *available at* https://transition.fcc.gov/oet/info/documents/technical/tm91-1.pdf.

[56] *Id*. at 1.

[57] The TM 91-1 model exactly matches the Egli model, and the TM 91-1 report discusses the Egli model in some detail. Yet the TM 91-1 report mysteriously never mentions that the resulting TM 91-1 formula

B. The Commission misapplied the TM 91-1 model while calculating path loss and distance.

The Commission committed three material errors in its application of the TM 91-1 model to calculate protection distances between unlicensed devices and WMTS systems. As explained below, each of these errors caused the Commission to underestimate the distances required to protect WMTS operations from harmful interference. Correcting all three of these errors, which must be done if the Commission hopes to adequately protect WMTS operations, would cause the TM 91-1 model to yield protection distances that are about triple the distances adopted in the *Part 15 R&O*.

First, in determining the protection criteria used in its latest analysis,[58] the Commission neglected to include a factor for the SNR required by WMTS radios. Instead, the Commission assumed the following: a receiver sensitivity of −100 dBm/10 kHz, a channel bandwidth of 12.5 kHz, a center frequency of 611 MHz, antenna aggregation gain of 3 dB, 0 dB building penetration loss, 2 dB loss due to antenna mismatch, polarization effect, line loss, and an I/N of

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is, in fact, the Egli formula. This raises significant questions about the actual intent of the TM 91-1 study: were the authors really trying to develop a "new" model that is valid at shorter distances, lower powers, and lower antenna heights as they claim in the report; or were they actually trying to find empirical data that supported a preconception that the Egli formula is valid for low power, non-broadcast services? The fact that the authors completely ignore the remarkable coincidence that the "new" model they developed exactly matches the old model that the FCC had relied upon for decades casts significant doubt on any assertion that the TM 91-1 study was an unbiased attempt to develop a new model. Other evidence in the TM 91-1 report, such as missing data points and mathematical inconsistencies, add to the doubt.

[58] The Commission's latest analysis abandoned without any explanation GEHC's proposed maximum field strength protection criteria, which it had used (albeit in conjunction with erroneous propagation calculations) in the *Part 15 NPRM*. Keeping that original protection criteria and correcting the propagation calculations would have resulted in much more reasonable protection distances—even applying the TM 91-1 model. For example, the smallest separation distance in the WMTS table of 380 meters would become 950 meters, and the largest distance of 11 kilometers would become 27.55 kilometers. *See Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, et al*., Notice of Proposed Rulemaking, 29 FCC Rcd 12248 ¶ 110 (2014) ("*Part 15 NPRM*"); *Part 15 R&O* ¶ 211.

−6 dB.[59] Specifically, the Commission's calculation assumed that reliable operation of WMTS radios could occur at signals that are at the receiver sensitivity and then applied the I/N of −6 dB to that value. In effect, this assumes that WMTS radios can operate when the noise floor is at the level of the receiver's sensitivity, or with a SNR equal to 0 dB. This is not the case.

This oversight caused the Commission to use an interfering signal level of −106 dBm (-100 dBm plus −6 dBm) in its calculations. However, this is an incorrect value that does not account for the required SNR of 10 dB. Properly accounting for the required SNR adds 10 dB to the required path loss, which would nearly double the protection distances adopted in the *Part 15 R&O*.[60] For example, by making only this change to the calculations, the smallest separation distance in the WMTS table of 380 meters would become 680 meters, and the largest distance of 11 kilometers would become 19.56 kilometers.[61]

Second, the Commission ignored the potential for multiple interferors. The Commission considered only what could happen in the case of a single interferor. If unlicensed use of the television white spaces is successful, however, there will be millions of white space devices in operation, and many will use Channel 37 out of necessity. Any given hospital could be the victim of dozens or even hundreds of unlicensed devices operating on Channel 37. Assuming only a single interferor thus underestimates the potential for interference to WMTS systems.

It is difficult to predict how prevalent of an effect multiple-interferor aggregation will become as white space devices proliferate. Even optimistically assuming a 3 dB factor, which corresponds to two equal signal strength interferors, would increase the protection distances to

[59] *See Part 15 R&O* ¶ 209.

[60] *See id.* ¶ 211.

[61] *See id.*

slightly more than double the distances identified in the *Part 15 R&O*.[62] For example, 380 meters of separation would become 810 meters, and 11 kilometers would become 23.25 kilometers.[63]

Third, as discussed above, the Commission's 10 meter or below assumption for WMTS antenna height is equivalent to about the 49th percentile of WMTS deployments. In other words, more than 50 percent of all hospitals have WMTS deployments that are located at a height that is greater than the Commission's assumption and thus are at significant risk of interference from unlicensed devices whose required separation distance from WMTS was based on an impermissibly lower height assumption. A more reasonable assumption would be to base the calculation on the 85th percentile, which would be about 20 to 22 meters. Using 20 meters WMTS height in the TM 91-1 model, along with the two changes discussed above, results in separation distances that are roughly triple the distances required in the *Part 15 R&O*. The results of this recalculation do not reflect an adjustment to account for the intrinsic variability of real-world propagation about the median, as discussed above,[64] which would further extend the separation distances.

Alternatively, the Commission could employ a different protection zone radius for each hospital based on the actual height of its deployment. As GEHC, Google, and Microsoft have

[62] *See id*.

[63] *See id*.

[64] *See* Section II.E, *supra*.

each noted, "a more nuanced approach" to calculating protection distances may best balance the competing interests in this case.[65]

C. Tests performed by GEHC and the WMTS Coalition earlier this year confirm that protection distances generated with the TM 91-1 model will not adequately protect WMTS systems from harmful interference.

GEHC and the WMTS Coalition (through its technical consultant, Comsearch) conducted tests earlier this year of the potential for interference to WMTS systems from white space devices at two separate hospitals in the Milwaukee area: Froedtert Community Memorial Hospital ("Froedtert") and Wheaton Franciscan Healthcare – Franklin Hospital ("Wheaton").[66] These tests assessed interference effects on the hospitals' existing WMTS systems from a simulated white space device and separately measured path loss between the simulated white space device and third party receive antennas that had been placed near actual WMTS receive antennas.[67]

The tests confirmed that the TM 91-1 model frequently overestimates path loss over short distances and line-of-sight conditions, both of which are probable near hospitals given the short protection distances adopted in the *Part 15 R&O*. At both hospitals, GEHC and the WMTS Coalition found that free space or near free space path loss could be expected from white space devices located outdoors at near ground level to the perimeter of the hospital.[68]

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[65] *See, e.g.*, GEHC Comments at 27-28; Reply Comments of Google, Inc., ET Docket No. 14-165, GN Docket No. 12-268, at 16 (filed Feb. 25, 2015); Reply Comments of Microsoft Corp., ET Docket No. 14-165, GN Docket No. 12-268, at 20-21 (filed Feb. 25, 2015).

[66] *See* Letter from Lawrence J. Movshin, Counsel, WMTS Coalition, *et al.*, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165, GN Docket No. 12-168 (filed July 20, 2015) ("WMTS Coalition *Ex Parte* Letter").

[67] *See* GEHC Froedtert Report at 3; GEHC Wheaton Report at 3.

[68] *See* GEHC Froedtert Report at 15-16; GEHC Wheaton Report at 15.

The tests also demonstrated that significant harmful interference can be caused to WMTS systems from even a single white space device operating at the power levels, separation distances, and height authorized under the rules the Commission had proposed. At Froedtert, the interfering signal needed to be reduced by at least 1 dB and up to 11 dB from the Commission's proposed levels at numerous test locations to avoid electrocardiogram ("ECG") waveform dropout.[69] At Wheaton, the interfering signal needed to be reduced by 6 dB from the Commission's proposed levels to avoid ECG waveform dropout.[70]

IV. THE COMMISSION INCORRECTLY INTERPRETED THE INTERFERENCE AND PATH LOSS TESTS PERFORMED BY GEHC AND THE WMTS COALITION AT THREE HOSPITALS.

The Commission misinterpreted both the results of the tests described above and the methodology used to conduct them. First, the Commission incorrectly assumed that GEHC and the WMTS Coalition placed third party receive antenna near hospital windows to increase the effect of interference observed on the WMTS system. In fact, third party receive antennas were used only for the path loss tests; the interference tests used existing WMTS antennas. Second, the Commission assumed that GEHC and the WMTS Coalition increased the risk of interference by using a directional antenna as the simulated white space device. In fact, due to an appropriate reduction of conducted transmit power, the use of a directional antenna did not affect the interference test results. An omni-directional antenna operating within the power limits set by the Commission would have produced the same results. Third, the Commission ignored the magnitude of the interference at several of the hospital test locations, which clearly demonstrates that even the revised protection distances adopted in the *Part 15 R&O* are insufficient to protect

[69] *See* WMTS Coalition *Ex Parte* Letter at 1.

[70] *See id*.

those locations form harmful interference. Fourth, the Commission ignored that the TM 91-1 model predicts more path loss than GEHC and the WMTS Coalition observed at many of the hospital test locations.

Meanwhile, the Commission ignored similar tests performed by GEHC and the WMTS Coalition at Inova Mount Vernon Hospital ("Inova").[71] There too, GEHC and the WMTS Coalition demonstrated that white space devices can interfere with WMTS systems when operating at the power levels, distances, and heights consistent with those allowed under the Commission's new rules.[72] The Inova tests also demonstrated how many sites near hospitals have a negative HAAT, as eight of the nine test locations there had negative HAAT at ground level that ranged from -26 to -27 meters.[73] The Commission failed to acknowledge, let alone address, the Inova tests.[74]

A. The Commission incorrectly assumed that GEHC and the WMTS Coalition placed receive antenna near hospital windows to increase the risk of interference.

The Commission concluded that GEHC and the WMTS Coalition's tests overestimated the potential for interference to WMTS systems because "all WMTS receive antennas [in the tests] were placed near windows pointing at the simulated white space transmitter."[75] In fact, GEHC and the WMTS Coalition's interference measurements did not use "placed" antennas. GEHC and the WMTS Coalition's interference measurements used existing antennas in live WMTS systems.

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[71] *See* GEHC Comments at 25-27; Inova Report.

[72] *See id*.

[73] *See* Inova Report at 12; *see also* Section II.B, *supra*.

[74] *See Part 15 R&O*.

[75] *See Part 15 R&O* ¶ 208.

As explained in the reports, the GEHC and WMTS Coalition tests included two types of measurements: path loss measurements and interference measurements.[76] For the path loss measurements, third party receive antenna were placed in close proximity to (*i.e.*, typically directly under) actual WMTS receive antennas.[77] Those WMTS receive antennas were often located on the ceiling near hospital windows,[78] which means that third party receive antennas were often located near windows too. Meanwhile, in a few cases, the tests positioned third party receive antennas near windows to better gauge path loss between the simulated white space device and the exterior of the hospital.[79]

The Commission appears to believe that GEHC and the WMTS Coalition used the third party receive antennas located near windows to measure interference under "the worst possible scenario."[80] However, GEHC and the WMTS Coalition used these third party receive antennas **only** to measure path loss, and even then their positioning typically mirrored that of actual WMTS systems antennas.[81]

In contrast, for the interference measurements, GEHC and the WMTS Coalition relied on unused channels in live WMTS systems.[82] Third party receive antennas were not placed in locations likely to maximize the risk of interference. In fact, third party receive antennas were not used at all. The parties used existing antenna placements in live WMTS systems as the

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[76] *See* GEHC Froedtert Report at 3; GEHC Wheaton Report at 3.

[77] See GEHC Froedtert Report at 8; GEHC Wheaton Report at 8.

[78] *See, e.g.*, GEHC Froedtert Report at 3 (noting that Froedtert had "multiple instances of a WMTS antenna located in a patient room with windows on any given floor").

[79] As explained below, GEHC and the WMTS Coalition were unable to take path loss measurements from a high floor outside either of the hospitals, which would have been their preferred approach.

[80] *See Part 15 R&O* ¶ 208.

[81] *See* GEHC Froedtert Report at 8; GEHC Wheaton Report at 8.

[82] *See id.*

WMTS receive antennas and placed WMTS transmit antennas (which are usually worn by patients) in realistic locations throughout the hospitals.[83]

B. The Commission incorrectly assumed that using a directional antenna as the source of interference affected the tests' interference results.

The Commission also incorrectly assumed that the GEHC and WMTS Coalition tests overestimated the potential for interference to WMTS systems because they used "a focused beam aimed directly at the hospital" as the source of interference.[84] In fact, GEHC and the WMTS Coalition used a directional antenna as the source of interference to prevent in-band interference at surrounding hospitals, and this choice did not affect the test results.

GEHC and the WMTS Coalition could have used an omni-directional antenna and still obtained the same results. Using an omni-directional antenna would not have changed the EIRP generated in the direction of the hospital, as a higher conducted transmit power would have accounted for the lower gain to achieve the same EIRP. Instead, GEHC and the WMTS Coalition took the gain of the directional antenna into account when setting the conducted transmit power level (subtracting it out of the path loss calculations).[85] In both cases, the EIRP in the direction of the hospital was exactly the EIRP allowed under the Commission's proposed rules.[86]

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[83] *See id*.

[84] *See Part 15 R&O* ¶ 208.

[85] The tests also accounted for the narrower bandwidth of the interfering signal. Since the interference tests utilized live WMTS systems, the interfering signal could not use the full 6 megahertz of Channel 37 or it would cause interference to live patients. Instead, the tests utilized 100 kHz of unused spectrum in Channel 37 and scaled the EIRP appropriately to account for the smaller bandwidth.

[86] *See, e.g.*, GEHC Froedtert Report at 3 (explaining that the tests used a single source of interference "with power level, separation distance, and height consistent with the proposed rules in the FCC Part 15 NPRM").

These testing methods were indicative of real-world scenarios likely to be encountered by hospitals. Fixed white space devices will generally be designed to cover 360 degrees around the transmit site and will therefore typically direct the maximum EIRP allowed by the Commission's rules toward hospitals. In other words, the Commission's rules do not require white space devices to limit antenna gain toward hospitals, and the worst case is that antennas are placed bore-site to a hospital. Moreover, the WMTS systems in these tests would still have experienced interference if only an edge of the beam had been pointed towards them. The gain at the edge of a directional antenna's horizontal beamwidth is only 3 dB less, and many of the GEHC and WMTS Coalition test sites showed a negative margin in excess of 3 dB.[87]

Additionally, the Commission should keep in mind that personal/portable white space devices will likely come in many different form factors, and that dozens or even hundreds of these devices may operate near a hospital. Thus, at any given time, a large number of personal/portable white space devices may be oriented towards the hospital and its WMTS system in the worst case.

C. The Commission ignored the significant magnitude of interference observed at several of the test locations.

The Commission noted that WMTS systems at the two Milwaukee hospitals tested experienced interference when simulated white space devices operated at 16 dBm from distances that were shorter than the revised protection distances adopted in the *Part 15 R&O*.[88] The Commission then concluded that, under the revised protection distances, all but one of the test locations "would be protected from interference from white space devices."[89] However, this

[87] *See* GEHC Froedtert Report at 15; GEHC Wheaton Report at 14.

[88] *See Part 15 R&O* ¶ 211 n.539.

[89] *See id.* ¶ 211.

conclusion ignores the significant magnitude of interference experienced by the hospitals in those cases.

In many cases, the interference observed by GEHC and the WMTS Coalition was very severe even though its source was very close to the revised protection distances adopted in the *Part 15 R&O*. For example, at one of the Froedtert hospital test locations, the WMTS system experienced severe interference when the simulated white space transmitter was 455 meters away.[90] The interference continued until the simulated white space device's power level was reduced by 11 dB, indicating an interference margin of -11 dB.[91] Although the separation distance used in this test is less than the revised distance of 480 meters for the specified power level and height, it is highly unlikely that the additional 25 meters of separation would generate 11 dB or more of additional path loss. In other words, the revised protection distances adopted in the *Part 15 R&O* are unlikely to prevent unlicensed white space devices from causing interference to those WMTS systems.

Moreover, as demonstrated in the table below, the maximum extra path loss due to distances adopted in the *Part 15 R&O* compared to those in the *Part 15 NPRM* is 2.1 dB for the 3 meter transmit antenna height. The three test reports show that many of the interference cases greatly exceeded the extra margin provided by these slightly greater protection distances: [92]

[90] *See, e.g.*, WMTS Coalition *Ex Parte* Letter at 1; GEHC Froedtert Report at 15.

[91] *See, e.g.*, *id.*

[92] *Compare Part 15 R&O* ¶ 211 *with Part 15 NPRM* ¶ 112.

	Distance for 3m TX Antenna		
EIRP (dBm) in 6MHz	**Proposed in the *Part 15 NPRM***	**Adopted in the *Part 15 R&O***	**dB Increase in FSPL Between *NPRM* and *R&O***
16	300m	380m	2.1
20	400m	480m	1.6
24	500m	600m	1.6
28	600m	760m	2.1
32	800m	960m	1.6
36	1km	1.2km	1.5

Three of the Froedtert test locations, one of the Wheaton test locations, and three of the Inova test locations would still experience interference under the Commission's revised protection distances because, at each of these locations, the margin required to eliminate interference was greater than 2.1 dB.[93]

D. The Commission ignored the implications of the TM 91-1 model predicting more path loss than actually occurred at many of the GEHC and WMTS Coalition test locations.

The Commission observed in a footnote that the TM 91-1 model predicts less path loss than GEHC and the WMTS Coalition measured at a number of the hospitals' test locations.[94] However, the Commission ignored the implications of this. Although the GEHC and WMTS Coalitions' measurements showed both more and less path loss than predicted by the TM 91-1 model, the Commission based its conclusions only on the measurements that showed more path loss. [95] This is clearly at odds with the Commission's stated goal of being "conservative in [its] determination of protection distances to protect WMTS."[96]

[93] See Froedtert Report at 14; Wheaton Report at 14; Inova Report at 12.

[94] *Part 15 R&O* ¶ 206 n.523.

[95] *See id.* ¶ 202; *see also id.* ¶ 211.

[96] *Id.* ¶ 202.

The path loss measured in the tests actually included both propagation loss and building penetration loss, as GEHC and the WMTS Coalition were not able to the take path loss measurements from a high floor outside either of the hospitals and, instead, measured path loss from inside of them.[97] As a result, those path loss measurements included the effects of building penetration loss, and the hospitals demonstrated how different construction materials affect propagation.[98] Froedtert opened in 1964,[99] whereas Wheaton opened in 2008.[100] Both use glass and other building materials that are characteristic of the time of their construction. For example, the windows at Wheaton use modern Low-E glass, which rejects RF signals much better than the clear glass windows Froedtert uses. These differences were reflected in the test results, just as they would be in the real world with WMTS systems operating in different hospitals made of different materials.

Although the TM 91-1 model predicts less path loss than was measured at the Wheaton test locations, it predicts *more* path loss than was measured at more than half of the Froedtert test locations.[101] Specifically, as applied by the Commission, the TM 91-1 model predicts between 1.7 dB and 20.2 dB more path loss than was observed at these five locations.[102] This means that it is possible for an actual interferor to generate more than 100 times the interfering power

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[97] *See, e.g.*, GEHC Froedtert Report at 8.

[98] Several of the path loss measurements at Wheaton had to be taken from a hallway because the hospital room nearest to the simulated white space device was occupied by a patient. At these locations, building penetration loss played a larger role.

[99] *See* Froedtert & Medical College of Wisconsin, *History*, http://www.froedtert.com/community-memorial/history (last visited Dec. 22, 2015).

[100] *See* Wheaton Franciscan Healthcare, *Our History*, http://www.mywheaton.org/about-wheaton/our-history/ (last visited Dec. 22, 2015).

[101] The TM 91-1 model predicts less path loss than GEHC and the WMTS Coalition measured at five of Froedtert's nine test locations.

[102] *See Part 15 R&O* ¶ 206 n.523.

predicted by the TM 91-1 model and that, in the real world, the TM 91-1 model is likely to predict more path loss than actually occurs at many hospitals.[103] The Commission appears to ignore this even though it professes to take a "conservative" approach to protecting WMTS operations from harmful interference. In an attempt to establish the "conservative" nature of its analysis, the Commission proffers that the TM 91-1 model "does not account for terrain features, buildings, and land cover that have an effect on the strength of received signals, nor does it consider multipath effects" and thus "may actually overstate the interference potential."[104] This claim suggests that the Commission is counting on—and essentially double-counting—those factors to provide additional protection over and above the loss predicted by the TM 91-1 model. It also demonstrates a fundamental misunderstanding of the TM 91-1 model and what it is predicting. According to the paper describing the Egli model, which is the same equation used by the TM 91-1 model, "irregularities of the terrain and the presence thereon of dispersed quantities of trees, buildings, and other man-made structures" are *precisely* the wave propagation encumbrances for which the effect (path attenuation) is being predicted.[105]

In addition, the GEHC and WMTS Coalition tests demonstrate that, even measured from inside hospitals, free space path loss is the more appropriate model in some cases. The path loss at two of the Froedtert test locations measured within 2 dB of the theoretical free space path loss.[106] This means that the building penetration loss through the windows was very close to zero dB and power levels inside the hospital were near their theoretical maximum level. For

[103] In particular, the TM 91-1 model is likely to predict more path loss than actually occurs at hospitals that are not constructed with materials that resist interference.

[104] *Part 15 R&O* ¶ 206.

[105] *See Egli Report*.

[106] The two were test location five and test location nine. *See* GEHC Froedtert Report at 15.

reference, the TM 91-1 model predicts 13.8 and 18.6 dB more path loss than GEHC and the WMTS Coalition observed at these two locations.

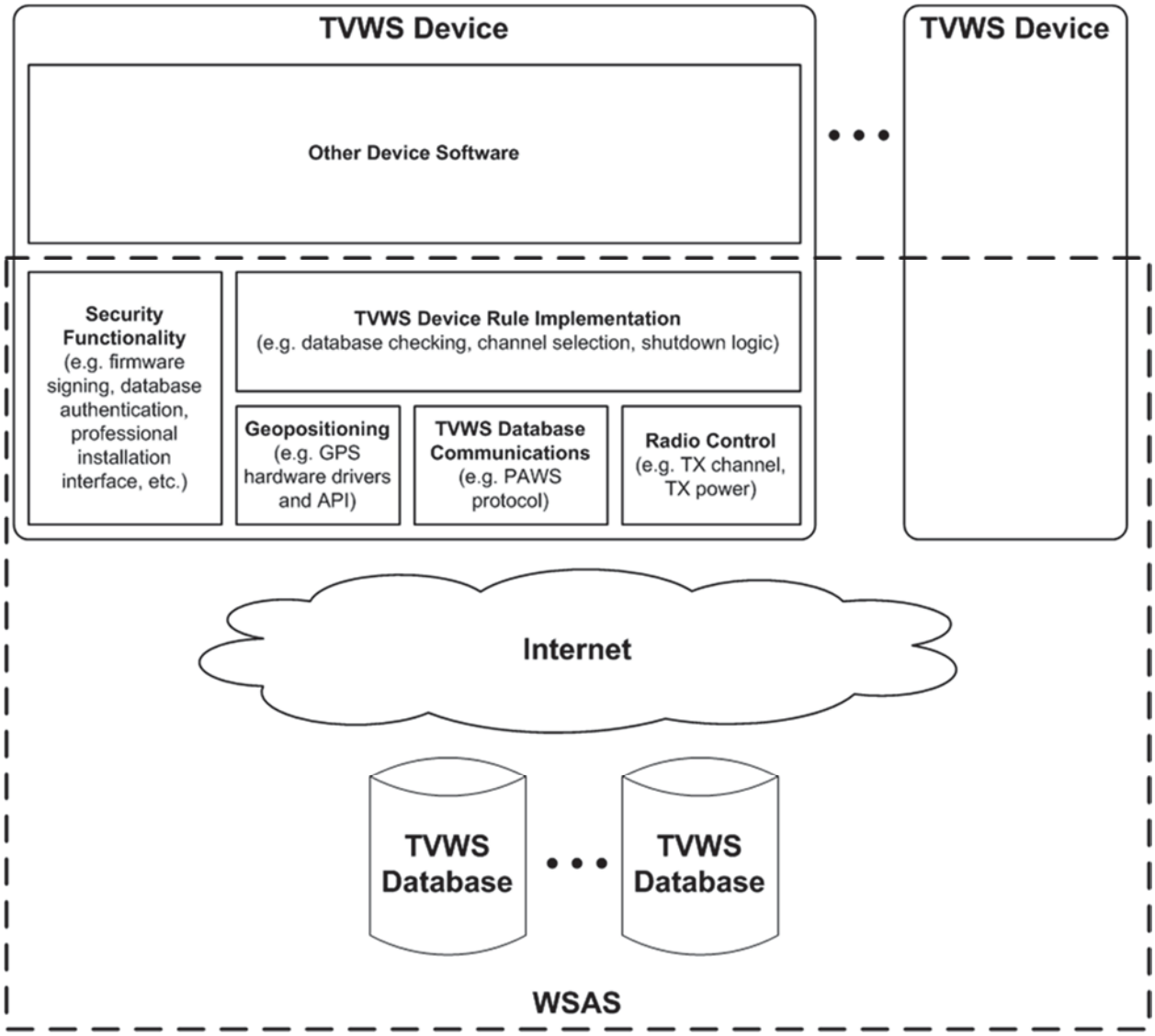
V. THE COMMISSION FAILED TO ADEQUATELY ADDRESS CONCERNS RAISED THROUGHOUT THIS PROCEEDING ABOUT THE DEPENDABILITY OF THE WHITE SPACE DATABASE AND DEVICES.

A. The Commission ignored the serious concerns related to the dependability of white space devices and the geolocation database scheme as a whole.

The envisioned geolocation database scheme entails a massive and complex, autonomous real-time distributed system (hereinafter referred to as the Whitespace Spectral Access System ("WSAS")[107] as depicted below in Figure 1.

[107] "WSAS" is a term used by GE Healthcare herein and is not to be confused with the Spectrum Access System ("SAS") as that term is used in the 3.5 GHz proceeding.

Figure 1



GEHC has highlighted dependability[108] concerns regarding the WSAS throughout this proceeding.[109] Of particular concern is that the critical Whitespace Spectral Access System ("WSAS") functionality (*e.g.*, geopositioning, database interface, radio control and security

[108] "Dependability" refers to system properties like reliability and security that allow a system to be relied on to function as required. "Reliability" is the probability of failure-free software operation for a specified period of time in a specified environment, and software is "secure" if it continues to function correctly under malicious attack.

[109] *See, e.g.*, GEHC Comments at 28; GEHC Reply Comments at 2, 9-14, Letter from Ari Q. Fitzgerald, Counsel, GEHC, *et al.*, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165, GN Docket No. 12-268 (filed July 31, 2015).

functions) residing in these devices will be software-based, undoubtedly including many open-source and commercial off-the-shelf software components.[110] Likewise, most of the white space devices are likely to be low-cost consumer-grade devices, subject to manipulation by third parties or the device owners themselves.[111] Although the Commission has recognized such concerns as they relate to software defined radios,[112] it failed in the *Part 15 R&O* to adequately address them as they relate to WMTS systems. Instead, the Commission observed in a footnote that it believed its current rules were "adequate to ensure security of the white space access systems" without addressing any of GEHC's specific points.[113]

Additionally, the WSAS has itself become a safety-critical system under the Commission's new rules because the continued interference-free operation of thousands of safety-of-life WMTS systems will depend on its reliable and secure operation. Specifically the Commission is relying upon the WSAS not only to prevent interference but also to be an essential tool for of remediation of any unexpected interference events. Therefore, **no matter what distance- or location-based separation rules the Commission adopts to protect Channel 37 WMTS operations from harmful interference, in order to dependably prevent unauthorized operations at locations near WMTS it must take steps to assure the *end-to-***

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[110] *See* GEHC Reply Comments at 9-10.

[111] *See, e.g.,* Thorin Klosowski, *How to Jailbreak your iPhone: The Always Up-to-Date Guide [iOS 8.1]*, Lifehacker.com (Oct. 31, 2014), http://lifehacker.com/5771943/how-to-jailbreak-your-iphone-the-always-up-to-date-guide-ios-61. "Jailbreaking" certain smartphones has become a ubiquitous practice by which individuals modify the security controls on their devices to install their own modifications to the device software that are otherwise not allowed by the operating system.

[112] *Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*; *Authorization and Use of Software Defined Radios,* Report and Order, 20 FCC Rcd 5486 ¶¶ 54-61 (2005) (requiring manufacturers to take steps to ensure that only software that has been approved with a software defined radio can be loaded into the radio); *see also* 47 C.F.R. § 2.944; GEHC Reply Comments at 10.

[113] *See Part 15 R&O* ¶ 195 n.490; *see also id.* ¶ 196 n.495.

***end* reliability and security of the entire WSAS that will implement and enforce those separation rules, including not only the databases but also the WSAS functionality (*e.g.*, geopositioning, database interface, radio control and security functions) that resides within consumer devices.**

Although not acknowledged by the Commission in the *Part 15 R&O*, there has at least been some recent recognition of concerns with the white space databases' accuracy,[114] and the Commission may soon release a notice of proposed rulemaking ("NPRM") to address them.[115] The Commission should ensure the scope of any NPRM related to the white space databases also encompasses other dependability concerns, including reliability, and should not allow white space devices to operate on Channel 37 unless and until those concerns can be addressed by that rulemaking.

B. The Commission should bolster required WSAS functionality to ensure that WMTS systems can depend on its reliable and secure operation.

To achieve the goals discussed above, GEHC requests that the Commission modify its rules to bolster the required WSAS functionality in at least the following respects:

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[114] *See, e.g.*, Amy Schatz, *FCC's Hot Mess of a Database May Not Bode Well for Future Airwaves Sharing*, RE/CODE (Mar. 17, 2015, 11:15 AM), http://recode.net/2015/03/17/fccs-hot-mess-of-a-database-may-not-bode-well-for-future-airwaves-sharing/ (observing that "it doesn't look anyone is keeping tabs on the accuracy of what's actually being added to the database"); Robert McDowell, *The FCC Should Fight For Our Right to TV White Space*, WIRED (Apr. 17, 2015, 3:36 PM) http://www.wired.com/2015/04/fcc-white-spaces-database/ ("These falsehoods aren't just humorous isolated errors; they number into the hundreds. And they show a cavalier attitude towards maintaining the integrity of the cornerstone of our next-gen tech economy.").

[115] The National Association of Broadcasters ("NAB") and a number of white space devices manufacturers recently proposed changes to the Commission's rules that would "vastly improve the accuracy of the TVWS database," which NAB had challenged in a petition for rulemaking filed earlier this year. *See* Letter from Haityun Tang, Adaptrum, Inc., *et al.*, to Julius P. Knapp, Chief, Office of Engineering and Technology, ET Docket No. 14-165, RM-11745 (filed July 17, 2015); NAB, Petition for Rulemaking, RM-11745 (filed Mar. 19, 2015).

- Allow only reliable, secure and accurate geopositioning technology, such as appropriately implemented GPS, and prohibit manual configuration of location device information;[116]

- Decrease the interval at which devices must renew their authorization with the white space database to at most ten minutes for fixed white space devices and at most one minute for personal/portable white space devices;[117]

- As part of the device authentication process, require databases to validate the revision and integrity of embedded software with respect to what is currently certified;[118]

- To the extent any professional installation is still allowed in lieu of secure and fully-automated geolocation, create a secure authentication process to validate the identities and credentials of professional installers (*e.g.*, through an electronic signature) and store professional installer information in the white space database as part of device registration to support compliance audits, investigations and enforcement actions;[119] and

- Require registration of personal/portable white space device information in the database to support interference investigation and remediation.[120]

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[116] *See, e.g.*, *id.*

[117] The Commission's current rules allow white space devices to operate for up to two days while disconnected from the white space database, which would cripple any "push" technology. *See* 47 C.F.R. § 15.711(b).

[118] "Firmware signing" technology is mature, robust, simple and inexpensive. It is used, for example, in gaming consoles to ensure that only software approved and licensed by the console manufacturer may run on the device. When security vulnerabilities or other bugs impacting WSAS functionality are inevitably identified after a device is certified and placed on the market the WSAS must be capable of suspending authorization for any devices containing the defective software and ensuring that necessary updates have been installed before authorizing the device to access spectrum.

[119] In response to rampant bogus device registrations identified by NAB, WISPA has suggested a formal certification process for professional installers. *See* Letter from Patrick McFadden, Vice President Spectrum Policy, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165, RM-11745, Attachment at 3 (filed June 30, 2015) ("NAB *Ex Parte* Letter"); Letter from Alex Phillips, Vice President and FCC Committee Chair, Wireless Internet Service Providers Association ("WISPA"), to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165, GN Docket No. 12-354, RM-11745 (filed July 9, 2015). Such a process, which should include provisions for periodic renewals, revocations and audits, is a *necessary but not sufficient* measure. However, the root cause of this issue is clearly inherent security vulnerabilities in the devices themselves.

[120] Under the Commission's current rules only fixed white space devices are required to register in the database. *See* 47 C.F.R. § 15.711.

C. The Commission should protect the integrity of the WSAS through robust enforcement of its rules for device security.

To better ensure that white space devices cannot be manipulated, the Commission should institute more thorough and robust enforcement of its rules, including Section 15.709(a)(6), which requires white space devices to "incorporate adequate security measures to prevent the devices from accessing databases not approved by the FCC and to ensure that unauthorized parties cannot modify the device *or configure its control features to operate inconsistent with the rules and protection criteria* set forth in this subpart."[121]

The FCC's existing device certification regime, which is essentially limited to black-box type testing and manufacturer attestation regarding the technical specifications of the device, is inadequate to ensure the reliable and secure operation of critical WSAS functionality embodied in white space device software.[122] Illustrating this, the National Association of Broadcasters ("NAB") recently found rampant false device registrations – including, most alarmingly, device location information upon which the effectiveness of the geolocation/database scheme depends entirely.[123] While this problem has been portrayed by white space proponents as simply a matter of database hygiene, in truth, such false registrations clearly demonstrate that: (1) many existing *devices* are inherently insecure and thus fail to comply with Section 15.709(a)(6) of the Commission's rules; and (2) that the Commission's current certification process is manifestly ineffective in preventing non-compliant devices from reaching the market. For example, at least one manufacturer makes its "professional installer manual" freely available on its website, so that any user can modify critical information (such as geolocation information upon which

[121] 47 C.F.R. § 15.709(a)(6) (emphasis added).

[122] GEHC Reply Comments at 10.

[123] *See* NAB *Ex Parte* Letter, Attachment at 3.

WSAS functionality depends) without authorization or authentication.[124] These insecure devices pose a security vulnerability to the entire WSAS and its dependability.

D. The Commission should take additional measures to help assure device and WSAS dependability.

Three additional measures would allow the Commission to more effectively implement existing and necessary future rules. First, the Commission should update the white space device certification procedures to require the applicant to provide additional detailed explanations for each of the following (for every database with which the device is designed to work):

- The geopositioning technology employed by the device, including its reliability, security and accuracy;
- The method used to secure all embedded software involved in WSAS functionality against unauthorized modification and to continuously update all software security and authentication methods according to any changes in the Commission's certification, security, or authentication standards and other industry standards;
- The method used to secure all software-configurable device parameters upon which proper WSAS functionality depends (*e.g.*, transmit power and the interval at which the device checks with database to renew its authorization) against unauthorized modification;
- To the extent any professional installation is still allowed in lieu of secure and fully-automated geolocation, the method used to securely authenticate professional installers, including validating their identity and ensuring that their individual credentials are current; and
- The software quality assurance and life cycle processes employed by the device manufacturer in the development, validation and maintenance of all embedded software involved in WSAS functionality.

Second, the Commission should establish procedures to identify, locate, recall, correct or disable devices found to be non-compliant after they have been certified and placed on the market. Third, the Commission should establish pre-market design control requirements, including

[124] *See* Adaptrum, ACRS 2.0 Professional Installer Manual, *available at*: http://www.adaptrum.com/acrs2launch/content/acrs20_professional_installer_02062014.pdf (last visited Dec. 22, 2015).

software quality assurance and life cycle processes for white space device manufacturers and procedures (*e.g.*, audits, corrective and preventive actions, etc.) to ensure manufacturers' compliance with design control requirements.[125]

VI. ESTABLISHING AN INSTITUTIONAL REVIEW BOARD COULD HELP MITIGATE THE THREAT TO PATIENT SAFETY CREATED BY UNLICENSED OPERATIONS ON CHANNEL 37.

The Commission's new framework is, as explained above, likely to leave safety-of-life WMTS operations vulnerable to harmful interference from unlicensed devices operating in close proximity to hospitals on Channel 37. In fact, the Commission itself seemingly acknowledges that there is some significant doubt about the adequacy of the rules and the risk to WMTS patients in proposing a "limited roll-out" to "validate and, if needed, adjust our approach."[126] To help mitigate the potential harms to hospitals and patients and assure the validity of any conclusions derived from these trials if it does not reconsider its decision to allow white space devices to operate on Channel 37, the Commission should consider implementing some of the procedures and policies set forth in the Department of Health and Human Services' ("HHS") rules.[127] These procedures provide a proven framework designed to protect vulnerable individuals who may be affected by agency testing, including "manipulation[] of the . . . subject's environment,"[128] and would be appropriate in this case given the potentially catastrophic consequences of even a single incident of harmful interference due to unintended

[125] *See, e.g.*, GEHC Reply Comments at 11-14 (explaining that software cannot be assumed to be dependable in the absence of rigorous quality assurance measures).

[126] *See Part 15 R&O* ¶ 221.

[127] *See* 45 C.F.R. § 46.101 *et. seq*.

[128] *See id*. ¶ 46.102(f).

levels of electromagnetic interference occurring at hospitals.[129] The Commission should apply them in the initial deployment of white space devices using Channel 37, which it has stated will cover "one or two" geographic areas.[130]

In particular, the Commission should develop an Institutional Review Board ("Board") to oversee and approve the initial deployment of white space devices on Channel 37. The Board should have at least five members with varying backgrounds, professional competence, and experience. At least one of these members should not be affiliated with the Commission to guarantee an "independent" perspective. The Board should be actively involved in the initial roll-out of white space devices on Channel 37. Its approval should be required for any such operation, and it should also have the authority to terminate any white space device operations that cause interference to WMTS systems. Additionally, the Commission should create a written document to guide the Board's activities, similar to the "assurance" required by the HHS' rules.[131] The document should include: the principles governing the Commission's final assessment based on evidence from the trial of whether white space devices can operate on Channel 37 at the protection distances adopted in the *Part 15 R&O*;[132] the designation of the Board to oversee these efforts;[133] and specific procedures that the Board will follow.[134]

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[129] *See, e.g.*, GEHC *Part 15 NPRM* Comments at 23-24.

[130] *See Part 15 R&O* ¶ 221.

[131] *See* 45 C.F.R. § 46.103.

[132] *See id.* § 46.103(b)(1).

[133] *See id.* § 46.103(b)(2).

[134] *See id.* § 46.103(b)(4).

VII. CONCLUSION.

The protection distances and other rules adopted in the *Part 15 R&O* will fail to protect many hospitals and WMTS systems from harmful interference caused by white space devices operating on Channel 37 because, as described above, the methodology the Commission used to develop these distances included a number of material errors. The Commission should eliminate these material errors and adopt new protection distances and other rules that will, in fact, provide adequate protection to WMTS systems from white space devices operating on Channel 37. The Commission should also create an Institutional Review Board to oversee the initial deployment of white space devices on Channel 37, which could help mitigate the potential harms to hospitals and their patients. Additionally, the Commission should reconsider its decision to allow white space devices to operate on Channel 37 before addressing the dependability concerns involving those devices and the geolocation-database scheme as a whole.

GEHC continues to engage with Google in cooperation with the WMTS Coalition on many of these issues. We sincerely believe that the alternative automated coordination approach that we and the WMTS Coalition have suggested and discussed with Google would be far better for all stakeholders than the Commission's current regime.[135]

[135] *See, e.g.*, ASHE July 21, 2015 *Ex Parte* Letter.

Respectfully submitted,

By: */s/ Ari Q. Fitzgerald*

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